NCDOT Congestion Management
CAPACITY ANALYSIS GUIDELINES

Traffic Impact Analyses or Studies

All guidelines from the *POLICY ON STREET AND DRIVEWAY ACCESS TO NORTH CAROLINA HIGHWAYS* (July 2003, pages 18-22) shall be followed. The values below serve as standard practices and default input values for traffic impact analysis reports (TIAs). Changes or deviations from these standards are allowed, but should be justified and documented. Failure to properly justify and document changes and deviations may result in the TIA being returned for changes, corrections and justification. A meeting regarding a scope of study is encouraged where significant deviations from standard practice are anticipated.

General

A site plan of the development shall be included in a TIA report. The site plan should provide sufficient detail to properly analyze the development. Details of what should be included on a site plan are listed in the *POLICY ON STREET AND DRIVEWAY ACCESS TO NORTH CAROLINA HIGHWAYS (JULY 2003)* pages 14-15. The site plan shall match the layout utilized in the TIA, or changes to the site layout included in the TIA should be listed. For TIA review purposes, an electronic copy of the site plan is acceptable, however the site plan should be easily legible when printed to a standard (22"x34") plan-size sheet.

For driveway requests that would require a break or change in Control-of-Access (C/A), a new median crossover, or both, such a change shall not be assumed. The TIA should show justification as to why the change in C/A or median crossovers is beneficial to the travelling public. An alternative that does not include these changes should be included in the TIA. This will provide a basis for comparison for the C/A or median crossover request. Changes in C/A will require approval from the Right-of-Way Disposal and Control-of-Access committee. New or modified median crossovers must be approved by the State Traffic Engineer for existing roadways, the Roadway Design Project Engineer for active TIP projects, and the State Highway Design Engineer for exceptions to the Median Crossover Guidelines on active TIP projects. These requests must be initiated by the District Engineer. For further information, please refer to the *MEDIAN CROSSOVER GUIDELINES* (effective January 2004) and the *RIGHT-OF-WAY DISPOSAL AND CONTROL-OF-ACCESS REVIEW COMMITTEE OPERATING PROCEDURES* (effective January 2006.).

Developments located near interchanges should follow the guideline to provide control-of-access 1000 feet beyond the ramp terminals. If this is not feasible, full control-of-access will extend for a minimum of 350 feet and a raised island will be installed to a point 1000 feet beyond the ramp terminals.

Access to developments on roadways designated as Strategic Highway Corridors may be restricted. In order to protect the safety, mobility and traffic carrying capacity of this

Strategic Highway Corridor, access along the corridor may be closed or relocated if an alternative access is developed in the future or if any safety concerns or other traffic impacts arise. Alternative operational methods should be investigated to maintain mobility on the corridor. Strategic Highway Corridor information may be found at www.ncdot.org/~shc

Developments impacting active TIP projects may require additional analysis to show the impacts on design year operations. These impacts may include additional traffic generated by the development not included in the traffic forecasts, or the impact of introducing a new driveway along the project corridor. Further guidelines for developments on TIP projects are currently being developed.

Trip Generation

In addition to the general policies set forth in the *ITE TRIP GENERATION MANUAL* and the *ITE TRIP GENERATION HANDBOOK*, the following practices and policies are utilized by the Congestion Management Section. It should be noted, these recommendations are in conjunction with the guidance of the *ITE TRIP GENERATION MANUAL* and *HANDBOOK* and are not in lieu of any procedures establish by ITE.

Identifying Land Uses

- To identify land uses correctly, read the land use description found in the *MANUAL* at the beginning of each land use section. The descriptions will explain the key traits of each land use and the features that differentiate it from other like land uses.
- Included in the land use description will be a list of like land uses. Read all the descriptions to establish the differences between the land uses and decide if the land use utilized in the study is the appropriate land use.
- Some land uses have very similar traits and their usage should be thoroughly investigated to ensure the correct land use is used. As examples, investigate the difference in business park and office park or convenience mart with gas pumps and gasoline/service station with convenience mart. Subtle differences between land use could result in an inaccurate analysis.
- Most land uses are described as stand-alone buildings; however, most developments can be broken up accordingly to identify trips based on specific land uses.
- If the submitted site plan identifies anchor retail building, or “big boxes”, the shopping center should be broken up into the specific land uses for analysis rather than uses the entire square footage as Land Use Code (LUC) 820, Shopping Center.

Analyzing Land Uses

- Most land uses have more than one variable. Verify that an appropriate variable is used in the study.
- Refer to the ‘RATE vs EQN.xls’ spreadsheet for the recommended variable for each land use.

- The most descriptive variable should be used; this would be the variable that would result in the largest variation in trips. Also, the variable should be measurable and provide the best fit for the trip generation data.
- In some instances, an alternate variable may be used. The validity of the variable should be verified through an analysis of the study data found in the *MANUAL*.
- The submitted site plan should provide verification for all variables used in the analysis.
- The proper calculation type (i.e., rate, equation, local data) should be used to estimate the trips generated.
- Refer to the attached 'RATE vs EQN.xls' spreadsheet to identify the recommended calculation type for the recommended variable for each land use.
- Refer to the *ITE TRIP GENERATION HANDBOOK* for the recommended process of selecting the appropriate calculation type for each land use.

Trip Reductions

- Pass-by percentages should only be applied to land uses with Land Use Codes in the 800s and 900s.
- For multi-use developments, pass-by percentages should be applied to the retail component only.
- Pass-by percentages, where applicable, should come from Chapter 5 of the *Handbook*. The average pass-by percentages these land uses are shown in the Pass-by Percentages.xls spreadsheet.
- Internal capture calculations should be used cautiously. Reductions for internal capture should be applied to multi-use, or mixed-use, sites only. A multi-use site must contain two or more land use types, i.e., retail, office, and/or residential. Refer to Chapter 7 of the *HANDBOOK* for further descriptions and explanations regarding internal capture trips.
- The internal capture calculation should utilize the percentages from Table 7.1 and 7.2 and Figure 7.3 from the *HANDBOOK* to estimate the internal capture reduction percentage.
- The internal capture reduction should be applied before the pass-by trips are calculated.
- Internal capture should not be taken from retail only sites, for AM peak hours, or from lodging land uses.

Signalized Intersections

Coordinated Signal Systems

- When analyzing multiple signalized intersections, the default should be to analyze as a coordinated signal system. Should the analysis procedure indicate that coordination is not recommended that information should be included in submittals.
- For coordinated signals, under recall, the usual condition will specify none for minor streets or movements, and the coordinated phase should be the main street through movement, typically phases 2+6.
- Cycle lengths for individual intersections in coordinated systems should be equal; double or half cycles can be used with justification.
- Use of the existing system cycle length should be used where known.

- It should not be the intent at the TIA development stage of a project to fully design and optimize a coordinated traffic signal system.

Auxiliary Lanes

- For analysis of future improvements, when protected left-turns are used, use protected only phasing not protected / permitted phasing. This analysis will identify the maximum queuing necessary in the event that protected-only phasing is necessary. In the design of the traffic signal, the use of protected/permitted phasing may be allowed.
- When analyzing existing signalized intersections, only use a leading phase sequence for protective/permitted phasing left turn movements, to prevent the yellow trap. Lagging operation is allowed for protective left turn movements only.
- Check for the possibility of using overlapping right-turn phasing where appropriate.
- For analysis of future operations, Right-Turn-On-Red (RTOR) operation should not be included. In the design of the traffic signal RTOR may be allowed. Exceptions will require justification and approval. To provide for a proper comparison, do not use RTOR for existing conditions.

Signal Timing and Phasing

- Total Lost Time – 5.0 sec/phase for most intersections, and increase clearance as needed for large cross sections such as a single point urban interchanges (SPUI).
- For existing traffic use yellow = 4 sec., red = 2 sec or existing timings. For analysis purposes, rounding up to the nearest second is preferred.
- For background and combined traffic use yellow = 5 sec., red = 2 sec. Clearance times using NCDOT criteria may also be used. Calculation sheets for these clearance times shall be included.
- The minimum initial green time for all protected left turn movements and all side street movements is 7 seconds.
- The minimum initial green time for the main street through movements is dependent on the speed limit and policy provided in the NCDOT Signals and Geometrics Design Manual. For 35 mph or less, use 10 seconds; for 36-45 mph use 12 seconds, for 46 mph or higher use 14 seconds.
- All cycle lengths should be rounded to the nearest 5 seconds.
- Phasing should remain consistent for all time periods. As an example, if split phasing is used for the AM peak, it must be used for the PM peak. Changing left-turn phasing from leading left to lagging left is dependent on the traffic signal controller equipment.
- Intersections with combination through/left-turn lane should have a split left-turn treatment for that approach. This is not a recommended geometric configuration, try to avoid if at all possible.

Recommended minimum cycle lengths by phase	
Number of Phases	**Minimum Recommended (seconds)**
2	60
3	90
4	110

5	110
6	140
8	140
Note: Maximum recommended cycle length is 180, but certain circumstances may warrant cycle lengths up to 240 seconds.	

Left Turn Treatment

Use protected left turn treatment (not protected/permitted) when (a) dual left turn lanes are present, (b) when left-turn lanes are crossing 3 or more opposing through lanes of traffic, or (c) when a condition is satisfied in the table below:

Number of Opposing Lanes (Through and Right)	Condition
1	Left Turn Volume * Opposing Volume > 50,000
2	Left Turn Volume * Opposing Volume > 90,000
3 or more	Left Turn Volume * Opposing Volume > 110,000

Additional Guidelines

The use of field values may be used in lieu of these standard values where conditions are not likely to change from the current operation.

- Full storage for queue lengths should be rounded up to the nearest 25 feet with a minimum of 100' for both right-turn and left-turn lanes.
- Due to uncertainty in determining between Rural and Urban conditions and predicting future land use, a PHF of 0.90 should be used, which is a median value between the 0.88 for Rural and the 0.92 for Urban conditions listed in the 2000 HCM. If field traffic counts have been acquired, the resulting PHF's should be used.
- Ideal Saturated Flow Rate = 1900 vphpl
- All efforts should be made to ensure that upstream and downstream traffic volumes along corridors balance and maintain continuity. If balanced volumes are not attainable, explanation should be provided.
- AM and PM Peak hour analysis should be performed for all reports; explanation should be provided for alternate time periods or to not perform an analysis for the AM or PM peak. The requirement to review other key analysis periods, such as a lunch peak or weekend peak, should be discussed with NCDOT prior to completion of the TIA.
- System analysis software (such as Synchro) should be used for arterials and multiple signalized intersections. Analysis procedures utilizing gap acceptance methodology (such as aaSIDRA) should be used for roundabout analysis. For unsignalized intersections, analysis based on HCM procedures should be used.

Synchro and SimTraffic

To facilitate review of the TIA, electronic copies of the Synchro data file should be submitted.

The values stated above should be correctly applied to the Synchro capacity analyses. Provided below are additional methodologies and inputs in Synchro that should be incorporated into the analyses.

- If there are existing protected/permitted left-turn treatments, lead/lag optimization should be fixed for lead operation for the respective phases.
- Any approaches or movements whose queue length are flagged by a "#" or a "m" should be reviewed for improvements given there may be serious delay and queuing problems for this approach or in the vicinity. These problems will need to be address in order for the intersection to operate properly.
- When creating a Synchro output report, the 'Intersection: Lanes, Volumes, and Timings' report will provide all necessary information for review.
- SimTraffic should be utilized to aid in verifying geometry, determining storage lengths and spotting other trouble areas. A SimTraffic queue analysis report should be included for review.
- Networks should be seeded for a period long enough to traverse the network including stops prior to recording. Also, the simulation should record for the entire one (1) hour period.

Highway Capacity Software 2000 (HCS2000)

General HCS Guidelines

- Due to uncertainty in determining between Rural and Urban conditions and predicting future land use, a PHF of 0.90 should be used, which is a median value between the 0.88 for Rural and the 0.92 for Urban conditions listed in the 2000 HCM.
- Provide output by means of the formatted report.
- Enter f_P = 1.00, unless in a tourist area, then use 0.95.

HCS Unsignalized Analysis

- Median storage should be zero as a standard unless there is sufficient width to provide adequate storage. Do not enter a storage exceeding one vehicle.
- Enter appropriate information from upstream (per direction) signalized intersections.
- Do not provide an overall level of service (LOS) for unsignalized intersections. According to the 2000 *HIGHWAY CAPACITY MANUAL*, LOS for an unsignalized intersection is determined by the computed or measured control delay and is defined for each minor movement. LOS is not defined for the intersection as a whole.

HCS Freeway Analysis

- Use the AADT, K (DHV), and D (directional split) provided by the Transportation Branch's forecast.

- Use the Base Free Flow Speed unless measured flow speeds are available. Base Free Flow Speed for an ideal freeway segment is 70 mph for urban conditions or 75 mph for rural conditions. However, this can be limited by design constraints. Therefore, this should be compared to the design speed of the facility and adjustments made to these inputs, as appropriate.

HCS Weaving Analysis

- The Weaving Section Analysis applies to weaving segments up to 2,500 feet maximum.
- Enter the Freeway Free Flow Speed (use the design speed or the posted speed plus 5 mph). Note: typical freeway situations have free-flow speeds of 65mph, collector-distributor (C-D) facilities are 45mph. The analyst can also use the base free flow speed to obtain an estimated free flow speed.
- Check Weaving Area Limitations to ensure that none of the limitations specified are exceeded. Where any limits are exceeded, consult the appropriate notes near the bottom of the output.

HCS Ramp Analysis

- For Freeway Free Flow Speed use the design speed or the posted speed plus 5 mph. Note: typical freeway situations = 65mph. You can also use the base free flow speed to obtain an estimated free flow speed.
- Typical Free Flow Speed for Ramps = 45 mph, and for Loops = 25 mph.
- Enter appropriate information for any adjacent ramps that exist within 6,000 feet of an analyzed on-ramp or within 1,400 feet of an analyzed off-ramp.
- If analysis indicates an LOS F and the freeway is not over capacity, extending the ramp acceleration/deceleration lengths could improve the LOS.

HCS Multilane Analysis

- Use the Base Free Flow Speed unless measured flow speeds are available. For Multilane Highways, Base Free Flow Speed may be estimated by increasing the speed limit by 7 mph for 40 and 45 mph, and increasing the speed limit by 5 mph for 50 and 55 mph.
- If no information is available for access points per mile, use 12 for rural sections and 25 for urban sections. If there is potential for rural section to become urban by design year, use 25. This includes right-side only access points.

HCS Two-Lane Highway Analysis

- Enter 100% no passing zones.
- If no information is available for access points per mile, use 12 for rural sections and 25 for urban sections. If there is potential for rural section to become urban by design year, use 25. This includes access points on both sides of the roadway segment.
- Use the Base Free Flow Speed unless measured flow speeds are available. For Two-Lane Highways, Base Free Flow Speed may be estimated by increasing the speed limit by 7 mph for 40 and 45 mph, and increasing the speed limit by 5 mph for 50 and 55 mph.

HCS Arterial Analysis

- Free Flow Speed may be estimated by the speed limit or default values found in the 2000 *HIGHWAY CAPACITY MANUAL.*

HCS Signalized Analysis

- Enter Right-turn-on-red (RTOR) as 0.
- Unless you have progressed movements use Arrival Type = 3.
- Enter Unit Extension (normally 3 seconds).
- Enter Start-up Lost Time (normally 7 seconds).
- Enter the Phasing Design. (use 5.0 seconds of yellow time and 2.0 seconds of red time).

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aaSidra

General Sidra Guidelines

- When creating a Sidra output report, the S7 and S15 reports will provide all necessary information for review.
- For proposed roundabouts a minimum lane width of 13 feet should be used.
- For proposed one-lane roundabouts a minimum of 120 feet should be used for the inscribed diameter (88-foot island diameter and 16 foot circulating road width). For proposed two-lane roundabouts a minimum of 148 feet should be used for the inscribed diameter (88-foot island diameter and 30 foot circulating road width).
- A roundabout should provide adequate level of service for a minimum of twenty years. A variable Flow Scale analysis for the roundabout or an analysis using future projected volumes should be performed to provide this information.

References

The *POLICY ON STREET AND DRIVEWAY ACCESS TO NORTH CAROLINA Highways* is the dictating standard related to all aspects of development access for the State of North Carolina. All pertinent standards found within this document shall be implemented during the analysis to provide for the safe, efficient, consistent treatment of driveway accesses.

Developments requesting median breaks shall adhere to the CURRENT *MEDIAN CROSSOVER GUIDELINES* when requesting a crossover.

Most signal standards can be found in the *TRAFFIC MANAGEMENT SYSTEMS UNIT DESIGN MANUAL*.

Congestion Management Website:
http://www.ncdot.org/doh/preconstruct/traffic/congestion/CM/default.html